REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
03/01/2011

2. REPORT TYPE
FINAL

3. DATES COVERED *(From - To)*
3/22/2010 - 09/21/2010

4. TITLE AND SUBTITLE
Integrated Miniaturized Materials - From Self-Assembly to Device Integration - Volume 1272

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00014-10-1-0588

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Carolos J. Martinez; Amit Goyal; Alberto Saiani; David Gracias; Rajesh R. Naik

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Materials Research Society
506 Keystone Dr
Warrendale PA 15086-7537

8. PERFORMING ORGANIZATION REPORT NUMBER
S1000 FINAL

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
ONR
230 S Dearborn Rm 380
Chicago IL 60604-1595

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

No restriction

20110307156

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Symposium OO intended to provide a forum for discussing what might be termed "complex self-assembly", even though it features "hierarchical self-assembly" in its title. The idea of the symposium is that the units of self-assembly themselves should have considerable complexity and/or programmability, and that this complexity should be reflected in the self-assembled structures that result, for example either allowing the construction of complex patterns at large length scales (perhaps hierarchically) or allowing construction into the 3rd dimension. To this end, the Symposium OO featured three tracks on three different aspects of self-assembly: (1) self-assembly based on the specific binding interactions afforded by biological molecules such as DNA and protein ("Biological materials"), (2) self-assembly of complex particle systems such as colloidal particles with specific and arbitrary shapes ("Complex particles") and (3) self-assembly of structures based on programmed structural changes in 2D materials to create more complex materials ("Folding, rolling and wrinkling").

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF: N/A			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	None	3	Donna J. Gillespie
					19b. TELEPHONE NUMBER *(include area code)* 724-779-2732

MRS Proceedings Volume 1272 (published in November 2010) contains papers presented at five symposia: **Symposium KK**, "Micro- and Nanofluidic Systems for Material Synthesis, Device Assembly, and Bioanalysis"; **Symposium LL**, "Directed Assembly and Self Assembly – From Synthesis to Device Applications"; **Symposium NN**, "Materials Exploiting Peptide and Protein Self Assembly – Toward Design Rules"; **Symposium OO**, "Hierarchical Self Assembly of Functional Materials – From Nanoscopic to Mesoscopic Length Scales"; and **Symposium PP**, "Interfacing Biomolecules and Functional (Nano) Materials." They were all held April 5-9 at the 2010 MRS Spring Meeting in San Francisco, CA.

The integration of miniaturized components is essential to enable new functional capabilities for materials and devices. This integration can be achieved using conventional planar lithographic methods; however, cost-effective integration at nanometer size scales and in three dimensions remains challenging. Hence, there is a need to develop novel methods such as self-assembly, which is rapidly emerging as a new methodology to synthesize ordered structures from micro- and nanoscale building blocks.

The papers presented are divided by the symposia at which they were presented, but have been collated in a single volume due to the numerous similarities and an overall theme of assembly and integration. The authors address the challenges in the cost-effective fabrication of miniaturized devices especially at small nano-sized scales and in three dimensions. These papers span a wide range of assembly methods including: molecular assembly methods with polypeptides and polynucleotides; rolling, wrinkling and self-folding of thin films; and self-assembly of lithographic structures using physical forces. Novel methods that seek to overcome challenges in enabling material and device designs for microfluidics and nanofluidics are included. Another area covered is that of biointerfaces and biomimetic materials with a focus on heterogeneous integration of materials from disparate material classes such as polymers, gels, and metallic & oxide-based nanoparticles.

Together, this collection of papers represents a comprehensive sampling of the state of the art of self-assembly and includes novel methods of device integration in micro- and nanotechnology. These are emerging fields and seek to transform electronics, medicine, optics, and the environment by enabling precisely nano- and micro-structured materials and devices on a hierarchy of length scales.

<u>Symposium OO Abstracts</u>

OO01-05, "Rolled-up helical nanobelts: from fabrication to swimming microrobots"
Li Zhang and Bradley J. Nelson, Inst of Robotics and Intelligent Systems, ETH Zurich, Switzerland

We present recent developments in rolled up helical nanobelts in which helical structures are fabricated by the self-scrolling technique. Nanorobotic manipulation results show that these structures are highly flexible and mechanically stable. Inspired by the helical-shaped flagella of motile bacteria, such as E. coli, artificial bacterial flagella (ABFs) are a new type of swimming microrobot. Experimental investigation shows that the motion, force, and torque generated by an ABF can be precisely controlled using a low-strength, rotating magnetic field. These miniaturized helical swimming microrobots can be used as magnetically driven wireless manipulators for manipulation of microobjects in fluid and for target drug delivery.

OO01-09, "Polymer tubes by rolling polymer bilayers"
Kamlesh Kumar[1,2], Bhanu Nandan[1], Valeriy Luchnikov[3], Svetlana Zakharchenko[1], Leonid Ionov[1], Manfred Stamm[1]
[1]Leibniz Inst of Polymer Research Dresden, Germany
[2]Oregon Health & Science Univ
[3]Inst de Science des Materiaux de Mulhouse, CNRS, Mulhouse, France

Polymer micro- and nanotubes are of growing interest for the design of microfluidic devices, chromatography, biotechnology, medical chemical sensors, etc. One approach for the design of tubes is based on the use of self-rolling thin films. Here we overview our recent progress in the fabrication polymeric self-rolling tube.

Polymer micro- and nanotubes have been demonstrated to possess remarkable applications in various fields such as microfluidic devices, chromatography, biotechnology, and medicine, and chemical sensors. Among different methods for preparation of tubes, stress-induced self-rolling of thin films deserved a particular interest. This method was originally developed for design of inorganic (metal and metal oxide) tubes. Recently, we applied this approach for fabrication of polymeric tubes. This paper overviews our recent developments in this field.

OO02-07, "Capillary and magnetic forces for microscale self-assembled systems"
Christopher J. Morris[1], Kate E. Laflin[2], Brian Isaacson[1], Michael Grapes[1] and David H. Gracias[2]
[1]U.S. Army Research Laboratory
[2]Johns Hopkins Univ

Self-assembly is a promising technique to overcome fundamental limitations with integrating, packaging, and generally handling individual electronic-related components with characteristic lengths significantly smaller than 1 mm. Here we briefly summarize the use of capillary and magnetic forces to realize two example microscale systems. In the first example, we use capillary forces from a low melting point solder alloy to integrate 500 μm square, 100 μm thick silicon chips with thermally and chemically sensitive metal-polymer hinge actuators, for potential medical applications. The second example demonstrates a path towards self-assembling 3-D silicon circuits formed out of 280 μm sized building blocks, utilizing both capillary forces from a low melting point solder alloy and magnetic forces from integrated, permanent magnets. In the latter example, the utilization of magnetic forces combined with capillary forces improved the assembly yield to 7.8% over 0.1% achieved previously with capillary forces alone.

OO06-05-LL06-05, "A moth-eye bio-inspired approach to planar isotropic diffraction"
Petros I. Stavroulakis, Stuart A. Boden and Darren M. Bagnall
Nano Research Group, Univ of Southhampton, United Kingdom

A regular hexagonally packed biomimetic moth-eye antireflective surface acts as a diffraction grating at short wavelengths of the visible spectrum and shallow angles of incidence. These gratings display strong backscattered iridescence with 6-fold optical symmetry. The optical symmetry of real moth eyes is effectively infinite as nature utilizes large number of uniquely oriented domains. In this work, we report on a biomimetic moth-eye surface created via nanosphere lithography with a very large distribution of close-packed tessellated domains and the resulting optical symmetry is compared to that of another widely known highly isotropic diffraction grating, also inspired by nature, the sunflower pattern.

A white-light laser reflectometry system is used to measure and compare the diffraction pattern isotropy from both structures. The tessellated close-packed structure diffraction pattern approaches that of infinite optical symmetry even though the underlying pattern only possesses a six-fold symmetry. Hence, the angular isotrophy observed for the sunflower pattern is replicated to a large extent via a self-assembly procedure, whilst circumventing the complicated design and manufacturing requirements of the sunflower pattern.